# BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

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## Section – 6(B)

## Technical Specifications for Single Panel Breaker (SPB)

## "Expansion of Distribution Automation System to Peri-Urban areas of Bangalore city, District Headquarters & Industrial areas across BESCOM Jurisdiction".

## Issued By


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# 1. Introduction

This document contains the Technical Specifications for Supply of SPB at head end of each 11kV Feeder Breaker, for BESCOM Distribution Network area.

## 1.1 Key SPB Components

Key SPB components are listed below:

- 11 kV 630 amps circuit breaker (CB) with earthing switch connecting the SPB to Trunk line, XLPE cables of size 400 Sqmm cross section aluminium /ACSR conductor.
- Numerical relay for overcurrent (OC) and earth fault (EF) protection in conjunction with the corresponding circuit breaker.
- All necessary voltage and current transformers for metering and protection.
- All necessary potential-free contacts for indications relevant to SPB monitoring and control remotely.
- Multifunction meter serving as Intelligent Electronic Devices (IEDs) to provide voltage, current, power, energy, phase angle between voltage and current of all the three phases, power angle and power factor readings.
- A power supply unit, including auxiliary power transformer and battery backup, to provide stable 24 VDC and 12 VDC sources of power for communication system respectively as well as necessary sources of power for the SPB's spring-charge motors, VPIS, relays, and multifunction meters. The power supply shall also provide for SPB enclosure lighting fixtures and power-plug receptacles for maintenance/test equipment.
- Capacitor voltage dividers serving live-line cable indicators with minimum one contacts for SCAD monitoring.

SPB shall have 2 enclosures; one for each of the circuit breakers and one for auxiliary power supply unit and the necessary SCADA monitoring and control equipment. The SCADA monitoring and control equipment includes the FRTU and communication accessories.

## 1.2 Single Panel Breaker (SPB)

Each SPB shall include its own power supply (including auxiliary power transformer, batteries, and battery charger), which shall provide a stable power source for not only for the SPB and but also for the RTU and any other communication system that the SPB must be capable of housing. The radio/ any other communication system will be supplied and installed by BESCOM.

Each new SPB shall be equipped with circuit breaker, meter and numerical relay. The SPB interrupters shall be enclosed in an vacuum medium, and the SPB will include all necessary voltage and current transformers and potential-free contacts so that, as a minimum, the DAS via its SPB remote interface can:

- Monitor and control the open/closed status of the circuit breaker.
- Monitor the open/closed status of the disconnector.
- Monitor the local/remote position of SPB manually-operated switches that can be used to enable and disable remote monitoring and control of breaker.
- Monitor the health of the power supply, which will include battery failure and low voltage indications.
- Monitor the open/closed status of circuit breaker earthing switch.
- Monitor the open/closed status of circuit breaker enclosure door.
- Monitor for low $SF_6$ gas pressure alarm
- Monitor circuit breaker and spring charge (switch readiness) status.
- Monitor for circuit breaker relay operations.
- Monitor for live line cable status for operation interlock.
- Monitor the number of operations of the SPB.
- Monitor voltage, current, power, energy, phase angle between voltage and current of all the three phases and power factor values corresponding to the SPB

## 1.3 Applicable Standards

The SPBs shall be manufactured to the highest quality consistent with best practice and workmanship and in full accord with the Contractor's quality assurance plan.

The contractor shall submit the details of the standards followed in the manufacturing of the SPB. The minimum required standards listed below.

**Table 1.1**

| Standard | Description |
|---|---|
| IS 3427 | AC metal enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV |
| IEC 62271-1 | High-voltage switchgear and controlgear – Part 1: Common specifications. |
| IEC 62271-200 | International Standards for high voltage metal clad switchgear up to 52 KV. |
| IEC 62271-102 | High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switches. |
| IEC 60529 | Standard for Degrees of Protection Provided by Enclosures (IP Code). |
| IS 9920 (Parts 1 to 4) | High Voltage Switches |
| IS 9921 (Parts 1 to 5) | Specification for AC disconnectors and earthing switches for voltages above 1000 V |
| IEC 62271-100 | Indian Standard for High-Voltage Alternating-Current Circuit-Breakers. |
| IS 10601 | Dimensions of terminals of HV Switchgear and Control gear |
| IS 12729 | General requirements of switchgear and control gear for voltages exceeding 1000 V |
| IS 2705 | Current Transformers |
| IS 3156 | Voltage transformers |
| IS 3231 | Indian Standards for electrical relays used in power system protection |
| IEC 60255 | Measuring relays and protection equipment |

The Contractor shall provide an English language copy of the applicable Indian and equivalent international standards met by the proposed SPB.

## 1.4 Environmental Conditions

All materials supplied shall be capable of operating without fault in a tropical climate, which exhibits a high level of ultra-violet radiation and severe thunderstorms. Relevant environmental conditions are listed as follows:

- Maximum ambient air temperature: 50 ºC
- Minimum ambient air temperature: 10 ºC
- Maximum relative humidity: 90 %
- Average thunder storm days per annum: 50
- Average rainfall per annum: 900 mm
- Maximum wind speed: 119 km/hr
- Altitude above mean sea level: 1000 m

# 2. SPB Design Features

All design features of the proposed SPB, shall be fully supported by the equipment actually supplied. The key design features include those that relate to:

- Availability, maintainability, expandability, and life span
- Ability to operate in severe outdoor environmental conditions
- Immunity to electrical stress and disturbance
- Acceptable insulation properties
- Acceptable surge suppression characteristics
- Convenient FRTU interconnection features

In these and all other specified respects, the SPB shall meet or exceed the cited standards or, where appropriate, other equivalent industry standards.

## 2.1 Availability and Maintainability

### 2.1.1 Availability

The SPB shall be designed to have a fully enclosed metal housing combined with the required insulation of all primary live parts to reduce the risk of internal faults to an absolute minimum and to provide a high degree of safety as well as availability. Nevertheless, manufacturer standard designs shall be used to the fullest extent possible.

Each SPB shall exhibit an availability of greater than 99.5%. To ensure this high degree of availability, the SPB shall be fabricated, assembled, and finished with workmanship of the highest production quality and shall conform to all applicable quality control standards. All materials comprising the SPB shall be new, unused, and of the best industrial grade, and the SPB shall incorporate all recent improvements in both design and materials. All components shall be of current production from reliable component manufacturers.

### 2.1.2 Life Span

Each SPB shall have a design life of at least 20 years from the date of final acceptance commission. The manufacturer shall make available, at no cost to the BESCOM, the manufacturing designs, drawings, and the rights to manufacture any subassemblies that the manufacturer will not support or discontinue to support during this life span. The specific components of each sub-assembly shall be identified and referenced in Contractor-supplied documentation.

### 2.1.3 Maintainability

The Employer intends to be self-reliant for SPB maintenance. To this end, the Contractor shall provide the support, documentation, and training necessary to operate and repair the SPB. This shall include, but shall not be limited to the maintenance manuals and repair kits applicable to the Contractor's SPB design. Details of the proposed repair kits shall be provided.

The Employer prefers SPB designs that do not require periodic preventive maintenance and inspections.

To facilitate maintenance, modularity shall be employed in the design of the equipment. All major subassemblies shall carry permanent labels providing a cross reference to the Contractor’s corresponding documentation.

## 2.2 Outdoor Features

### 2.2.1 General

The SPB shall be designed specifically for outdoor installation and, in this respect, shall be suitable for continuous operation in a tropical climate that includes exposure to severe frequently occurring thunderstorms. They shall also be suitable for conditions in which they will be exposed to heavy industrial pollution, salt-spray, and high levels of airborne dust.

The SPB shall be conformably coated to meet these climatic conditions. In this respect, standard IEC covering equipment, systems, operating conditions, and environmental

conditions, which covers the classification of such conditions. In particular, the SPB shall have been type tested for continuous operation under the standard environmental conditions.

In addition to the above, materials promoting the growth of fungus or susceptibility to corrosion and heat degradation shall not be used, and should provide rodent proof installations.

### 2.2.2 Corrosion Protection

Except for stainless steel, all steel surfaces that are not galvanized shall be treated to protect against corrosion. As a minimum, corrosion treatment shall include the following procedures:

- The surface shall be cleaned to bare material by mechanical or chemical means.
- One or more phosphatizing or priming coats of paint shall be applied to the bare surface using a zinc-based or epoxy primers.
- A finish coat with high scratch resistance or epoxy powder finish paint shall be applied over the primer. The coat thickness shall be of the order of 120 micrometres.
- The finish-coat color should be RAL-7032.

### 2.2.3 Galvanizing

Except for stainless steel, and unless otherwise stated, all structural steel and all exterior and interior steel surfaces of the SPB, as well as nuts and bolts associated with galvanized parts, shall be hot-dipped galvanized in accordance with IS 802 or an equivalent international standard.

## 2.3 Immunity to Electrical Stress and Disturbance

The electrical and electronic components of the SPB shall conform to relevant standards concerning insulation, isolation, and immunity from electromagnetic interference, radiated disturbance, and electrostatic discharge. The ability to meet these requirements shall be verified by type tests carried out by accredited test laboratories that are independent of the bidder and/or the manufacturer of the SPB components. Certified copies of all type test certificates and test results shall be included as part of the bidder's proposal. Failure to conform to this requirement shall constitute grounds for rejection of the proposal.

## 2.4 Minimum Insulation of Equipment

The SPB shall be of $SF_6$ gas-insulated type, shall have required minimum insulation level.

## 2.5 Surge Voltage Suppression

The SPB equipment shall be designed to operate on input power containing voltage spikes. Equipment shall be protected against part failure or malfunction such as intermittent firing of triggering devices due to surge voltage spikes occurring randomly over the instantaneous supply voltage.

## 2.6 Name plate Information

SPB nameplate information shall be as specified in the relevant IEC standards (IS 12729:2004 & IS/IEC 62271-200:2003) along with following additional information :

- Name of manufacturer and country
- Type, design, and serial number
- Rated voltage and current
- Rated frequency(f)
- Rated short duration power frequency withstand voltage (Ud)
- Rated lightning impulse withstand voltage (Up)
- Short time withstand current and its duration.
- Rated symmetrical breaking capacity
  Rated making capacity
- Auxiliary control voltage (Ua)
- Internal Arc Classification.
- Operating cycle.
- Month and year of supply
- Purchase Order number and date
- Project details
- Height and Weight of the SPB
- SF6 pressure details.
- Protection relay details.

The name plate and a BESCOM logo shall be engraved with all the above information and Each SPB shall also exhibit a Danger Board to indicate the presence of high voltage (11,000 V).

## 2.7 Interconnecting Cables, Wiring, Connectors, and Terminal Blocks

All interconnecting wires, cables, connectors, terminations and other wiring accessories such as terminal blocks required by the SPB shall be provided by the contractor.

### 2.7.1 Metallic Cables

All metallic cables and wiring shall be of required cross-section multiple strands of round copper conductors and have flame retardant insulation. All wiring shall be neatly laced and clamped.

All wire and cable connectors and terminators shall be permanently labeled for identification. All connection points for external cables and wires shall be easily accessible for connection and disconnection and shall be permanently labeled. Conductors in multi-core cables are color-coded for AC circuits.

### 2.7.2 Connectors

Plug-type connectors with captive fasteners shall be used for all interconnections. The connectors shall be polarized to prevent improper assembly.

### 2.7.3 Breaker-FRTU Connectors

For ease of installation and maintenance, the interconnection between the circuit breaker and the FRTU in a separate enclosure, shall be supported by having a multi-pin connector installed in each and every enclosure.

To accommodate all of the SPB equipment points to be monitored and controlled, the connector installed in the enclosure (the Control Cabinet) containing the FRTU shall consist of 2 multi-pin connectors as illustrated in Table 2-1.

Final connector, control cabling, and control cable routing details has been finalized and is available. In this respect, however, the following concepts shall apply:

- The Control Cabinet's fixed connector shall consist of 2 individual multipin(depending on the enclosures) connectors having 24 female inserts and contacts capable of being wired to the FRTU and to single multi-pin connectors of female type fixed in the control cabinet enclosures via separate hooded plugs having 24 male inserts and contacts attached to cables

of suitable length. The FRTU male connector and its cable shall be provided by the contractor.

- All cabling for the SPB's analog and status input points, control output points, and auxiliary contacts, status points of breaker and disconnector shall be brought out to the multi-pin connectors in the SPB enclosures.
- Wiring between the single female connectors in the breaker's enclosures and the female connectors in the Control Cabinet shall take the form of Contractor-provided cables having at both ends a corresponding male connector.
- The female multi-pin connectors shall contain a locking lever so that, in combination with the male connectors, they shall act as a mechanical locking device between male and female connector pairs. The lever shall only be fully locked if the two connectors are mated correctly.

### 2.7.4 Terminal Blocks

Apart from the connectors described above, heavy-duty terminal blocks with screw type terminals for 5 mm minimum machine screws shall be provided by the Contractor for other necessary metallic cable terminations. Terminals for auxiliary relays shall equal or exceed the relay wiring requirements. In using a terminal block, no more than two cables or wires shall be connected to any of its individual terminals.

Self-extinguishing fireproof vinyl marking strips shall be used to identify all external connection blocks. Marking tags shall be read horizontally. All terminals to which battery or other high voltages are connected shall be provided with fireproof covers.

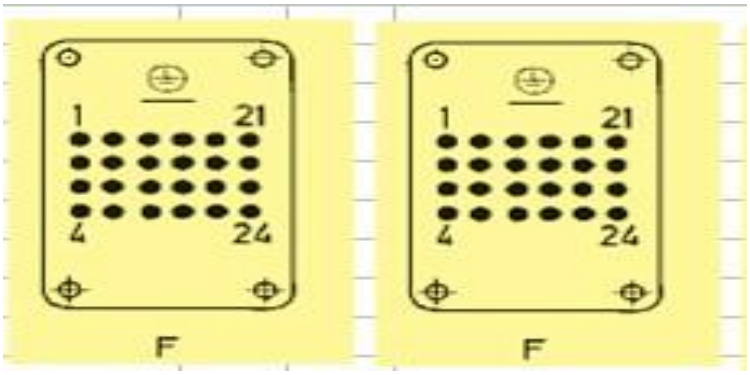
All individual status input, AC voltage input, and control output points shall be isolatable without the need to remove wiring by means of individual terminal blocks of the removable link type. In order to avoid open circuits on the secondary side of CTs, termination blocks with by-pass bridges shall be provided for all AC current inputs.

Terminal blocks shall comply with latest IEC standards.

**Table 2-1: SPB/FRTU Connector Pin-Out**

| Pin Nos | | Circuit Breaker (CB) | Pin Nos | | Miscellaneous |
|---|---|---|---|---|---|
| 1 | 2 | CB : closed | 1 | 2 | SF6 pressure : low |
| 3 | 4 | CB : open | 3 | 4 | Charger AC: fail |
| 5 | 6 | Spring : charged | 5 | 6 | Voltage DC: low |
| 7 | 8 | Earth switch : closed | 7 | 8 | Battery alarms: Battery -failed, etc. |
| 9 | 10 | Earth switch : open | 9 | 10 | Battery Temperature |
| 11 | 12 | Spare | 11 | 12 | Control Cabinet door open |
| 13 | 14 | Spare | 13 | 14 | Battery compartment door :open |
| 15 | 16 | CB: Local/remote status | 15 | 16 | DI indication for execution of DO command for open and close of CB |
| 17 | 18 | CB Control: close | 17 | 18 | Hooter reset |
| 19 | 20 | CB Control: open | 19 | 20 | I/c cable Door: open |
| 21 | 22 | O/g cable Door: open | 21 | 22 | Incoming cable VPIS indication |
| 23 | 24 | Disconnector : open/close | 23 | 24 | Outgoing cable VPIS indication |

* MFM & Relay parameters are controlled through Modbus. Hence these points are kept out of Pin out.




CB MISC

# 3. SPB Characteristics

As a minimum, the SPB shall be equipped with numerical relays for the protection and multifunction meter providing voltage, current, power, phase angle between voltage and current of all the three phases, energy, and power factor readings. SPB shall be of SF6 insulated and vacuum interrupter type.

In addition, each SPB shall be equipped with all necessary connectors, terminal blocks, and other accessories that will allow the FRTU to send required breaker/distribution network indications and measurements to the DAS via the communication system.

## 3.1 General Requirements

Each SPB shall include its own power supply, including battery and battery charger, and provisions for supplying a stable source of power for the FRTU and also to the radio/any other communication system to be housed by the SPB. Thus, the SPB shall also provide the necessary space for installing radio/any other communication system supplied and installed by employer.

Within this context, the general requirements of the SPB shall include, but shall not be limited to provision of the following monitoring and control features:

- Positions of local/remote switches as used to control local and remote access to circuit breaker.
- Power supply indications including battery failure and voltage alarms.
- Open/closed position of circuit breaker, disconnector and earthing switch.
- Enclosure door-open indications.
- $SF_6$ gas-pressure low alarm.
- Circuit breaker spring charge (switch readiness) indications.
- Circuit breaker relay indications.
- Measurement of voltage, current, power, phase angle between voltage and current of all the three phases, energy, and power factor values.
- circuit breaker open/close control.
- Change of Relay group settings.
- Relay trip Reset control.

The acceptance of the SPB shall not be complete until they have been demonstrated on a point-to-point basis to be fully interoperable with the SPB

## 3.2 Parameter Requirements

The minimum design parameters to which their major components shall conform or exceed are summarized in the following tables.

Table 3-1: System Parameters

| **Parameter** | **Value** |
|---|---|
| Nominal System Voltage | 11 kV |
| Highest System Voltage | 12 kV |
| System frequency | 50 Hz |
| Number of Phases | 3 Phase |

Table 3-2: Circuit Breaker Parameters

| **Parameter** | **Value** |
|---|---|
| Nominal System Voltage | 11 kV |
| System frequency | 50 Hz |
| Number of Phases | 3 Phase |
| Lightning Impulse Withstand Voltage<br>Phase-to-Phase & Phase-to- Earth | 75 kV (peak) |
| Power Frequency Withstand Voltage to<br>Earth, Between Poles | 28 kV rms for 1 minute |
| Rated Short Time Withstand/Making | 50 kA (rms) |
| Nominal System Voltage | 11 kV |
| System frequency | 50 Hz |
| Number of Phases | 3 |
| **Current** | |
| Rated Short Time Withstand/Breaking Current: | 21 kA (rms) |
| Rated Duration of Short Circuit: | 3 seconds |
| Rated Normal Current: | 630 Amps (rms) |

The SPB shall be capable of withstanding the specified currents without damage in accordance with IEC 62271-102 and IEC 62271-1 (Common Specifications for High-Voltage Switchgear and Control Gear Standards) and IS 3427 (AC Metal Enclosed Switchgear and Control Gear for Rated Voltages above 1 kV and up to and including 52 kV).

## 3.3 Design Details

- The SPB shall be designed to operate at the rated voltage of 11 kV. It shall consist of one number of 630 Amp $SF_6$ insulated bus bar chamber and vacuum interrupter.
- It shall include, within the same metal enclosure, disconnector switch and Circuit Breaker. The Disconnector shall be between Circuit breaker and Cable bushings.
- Suitable fool-proof interlocks shall be provided to the earthing switch to prevent inadvertent or accidental closing when the circuit is live and Circuit Breaker is in its closed position.
- The degree of protection required against prevailing environmental conditions, including splashing water and dust, shall be not less than IP 67 or better as per latest IEC standards.
- The active parts of the switchgear shall be maintenance free.
- The tank shall be made of an adequate thickness of stainless steel or metallised cast resin and shall be internally arc tested.
- The SPB shall be suitable for mounting on its connecting cable trench.
- For each SPB enclosure, a suitably sized nameplate clearly identifying the enclosure and the electrical characteristics of the enclosed devices shall be provided.
- The positions of the different devices shall be clearly visible to an operator when standing in front of each enclosure with its door open. Device operations shall be clearly visible.
- The SPB design shall be such that access to live parts shall not be possible without the use of Constructor-supplied tools.
- The design shall incorporate features that prevent any accidental opening of the earth switch when it is in the closed position. Similarly, accidental closing of a Circuit Breaker shall be prevented when the same is in an open position. This includes protection against accidental closing resulting from the release of any latch or spring in tension due to vibrations caused externally or internally.
- The opening between Feeder compartments and Control cabinet compartments shall be made vermin proof.
- A number lock/Digital lock of adequate size shall be provided to RTU Control Cabinet.

- Control Cabinet shall include a minimum contiguous space of 700 mm (W) x 600mm (D)x700mm(H).
- A suitable provision shall be made to replace only metallic portion of bushing/ part of Bushing without opening of the SF6 chamber, when cable bushing threads are burnt out. The design should ensure that the replacement process does not compromise the sealing integrity of the SF6 gas chamber.
- Minium gap between bushing to bushings inside all the cable compartments for proper cable termination will be finalized during design stage.
- Minium gap inside all the cable compartments will be finalized during design stage.
- To avoid opening of Battery compartment by un-authorized personnel a theft proof arrangement along with annunciation with alarm sufficient decibel shall be provided.
- Access to the battery compartment shall be secured by a tamper-proof locking mechanism with sturdy enclosure. Unauthorized opening shall be detected and shall activate a local audible annunciation system with a sound level not less than 100 dB. Provision shall be made to monitor unauthorized opening and reset the activated annunciation system remotely.

## 3.4 Earthing

- There shall be continuity between metallic parts of the breaker and cables so that there is no dangerous electric field in the surrounding air and the safety of personnel is ensured.
- The SPB frames shall be connected to the main earth bars, and the cables shall be earthed by an Earth Switch having the specified short circuit making capacity.
- The Earth Switch shall be operable only when the main switch is open. In this respect, a suitable mechanical fail-proof interlock shall be provided.
- Disconnector & earth switch shall be in between Circuit Breaker and Cable Bushings.
- The Earth Switch shall be provided with a reliable earthing terminal for connection to an earthing conductor having a clamping screw suitable for the specified earth fault conditions. The connection point shall be marked with the earth symbol. The

flexible connections between the earthing blade and the frame shall have a cross-section of at least 50 $mm^2$ copper or equivalent in aluminum.

- The Earth Switch shall be fitted with its own operating mechanism. In this respect, manual closing shall be driven by a fast acting mechanism independent of the operator's action.

## 3.5 Circuit Breaker

The Circuit Breaker shall be maintenance free and, when standing in front of the SPB with enclosure doors open, their positions shall be clearly visible. The position indicator shall provide positive contact indication in accordance with IS 9920. In addition, the manufacturer shall prove the reliability of indication in accordance with IS 9921: Alternating Current Disconnectors (Isolators) and Earthing Switches for Voltages above 1,000 V.

The breakers shall have two positions (or states), i.e., Open and Closed. and shall be constructed in such a way that natural interlocking prevents unauthorized operations. They shall be fully assembled, tested, and inspected in the factory.

An operating mechanism shall be used to manually close the Circuit Breaker and charge the mechanism in a single movement. It shall be fitted with a local system for manual tripping. There shall be no automatic reclosing. The Circuit Breaker shall be capable of closing fully and latching against the rated making current. Mechanical indication of the OPEN, CLOSED positions of the Circuit Breaker shall be provided.

When the Circuit Breaker closing mechanism is of the spring operated type, it shall not be possible for the Circuit Breaker to close until the spring is fully charged and the associated charging mechanism is fully ready for closing. Wherever an external spring charging handle is required to charge the spring, it shall be ensured that the same is not allowed to move during release of the spring energy. Alternatively, it shall not be possible to release the spring energy until the charging handle is completely disengaged from the mechanism. A visual mechanical indicating device shall be provided to indicate the status of the spring, i.e., SRING CHARGED or SPRING FREE. It shall be possible to charge the spring when the Circuit Breaker is closed and, if the spring is released, the Circuit Breaker shall not open. Nor shall this operation result in any mechanical damage to the component of the Circuit Breaker or its operating mechanism. Alternatively, a fast acting reflex mechanism for Circuit Breakers is also acceptable.

Circuit Breaker shall operate in conjunction with a suitable protection relay under phase and earth fault conditions. In addition, the Circuit Breaker shall be provided with a motorized operating mechanism that can be remotely controlled by the DAS and motor assembly should be inside enclosures.

## 3.6 Cable Termination

Bushings shall be conveniently located for working with the specified cables and shall allow for the termination of these cables in accordance with the prevailing practice and guidelines of cable manufacturers. The dimensions of the terminals shall be in accordance with IS 10601. A provision shall be made to replace only metallic portion of bushing/ part of Bushing without opening of the SF6 chamber, when cable bushing threads are burnt out.

A non ferro-magnetic cable clamp arrangement shall be provided for each cable to be terminated in the single breaker panel .

A suitable arrangement for the Circuit Breaker, Earthing Switch shall be provided so that these devices can be padlocked in the "Open" and "Closed" positions.

A permanent "Live Cable" indication as per IEC 61958 (High-Voltage Prefabricated Switchgear and Control Gear Assemblies - Voltage Presence Indicating Systems) shall be provided for each cable using a capacitor voltage divider suitable for SCADA. Potential free contacts shall be provided with VPIS for remote monitoring.

It shall be possible to test the core or sheath insulation of the cables without deenergizing the remaining section of the SPB, accessing the cable compartment, or disconnecting the cable.

## 3.7 Safety of Equipment

With respect to the SPB's $SF_6$-filled equipment, any accidental overpressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the enclosure so that the gas will be released away from the operator without endangering the operator or anyone else in the vicinity of the SPB.

## 3.8 Front Plate

The front plate shall include a clear mimic diagram indicating single breaker panel functionality. The position indicators shall correctly depict the position of the main contacts and shall be clearly visible to the operator. The lever operating direction shall be clearly indicated. Mimic diagram shall be resistant to scratches and cleaning chemicals, also UV resistant and non-fading. It shall be fixed or embossed permanently on the RMU front door.

## 3.9 Line sensors

The single breaker panel shall be provided with current sensors and voltage sensors. These sensors shall meet the electrical and mechanical ratings as per the relevant standards.

## 4.1 Current Transformers

The SPB shall be provided with 3 numbers of CT's with two core secondary for metering and protection purpose or 6 numbers of single core secondary CTs for metering and protection purpose (3 numbers of CTs for Metering & 3 numbers of CTs for Protection) . CT access for maintenance or any other purpose shall be from the front, back, or top of these panels.

The CTs shall conform to IS 2705 and amendments if any. The design and construction shall be sufficiently robust to withstand thermal and dynamic stresses during short circuits. Secondary terminals of CTs shall be brought out suitably to a terminal block, which will be easily accessible for testing and terminal connections.

Further, the CTs shall be single core or multi core, the characteristics and features distinguishing CTs used for metering and CTs used for protection are listed as follows:

**CTs for Metering:**

- Material: Epoxy resin cast
- Burden: 2.5VA
- Ratio: 400-200/1 A
- Accuracy Class: 0.2S.

**CTs for Protection:**

- Material: Epoxy resin cast
- Burden: 5VA
- Ratio: 400-200/1 A
- Accuracy Class: 5 P 20.

**OR**

| Particulars | Metering (Core1) | Protection (Core 2) |
|---|---|---|
| **Material** | Epoxy resin cast | Epoxy resin cast |
| **Burden** | 2.5VA | 5VA |
| **Ratio** | 400-200/1 A | 400-200/1 A |
| **Accuracy class** | 0.2S | 5 P 20 |

## 4.2 Voltage Transformer

Three numbers of potential transformers shall be provided. The burden per transformer shall be no more than 50 VA and the voltage ratio shall be 11kV/√3/110V/√3. The accuracy class shall be 0.5. HRC fuses shall be provided on the HV side.

The PTs shall be of cast epoxy-resin construction, and they shall conform to IS 3156. Their design and construction, in particular, shall be sufficiently robust to withstand the thermal and dynamic stresses during short circuits.

# 5 Protection Relay

The SPB shall be equipped with SCADA based numerical relays as used to trip the circuit breaker.

## 5.1 General

- The Circuit Breaker enclosures in the SPB shall be outfitted with a communicable type numerical (feeder protection) relay. The protection relay's auxiliary contacts shall be hardwired to the FRTU. The relay shall also interface with the FRTU via an RS 485 port in order to send, as a minimum, real-time phase current readings using the MODBUS protocol.
- The numerical relay shall be powered by the SPB's power supply unit and shall be provided with Inverse Definite Minimum Time (IDMT) and Instantaneous protection characteristics. On this basis, the relay as a minimum shall provide:
    - Phase Overcurrent Protection (50/51)
    - Earth Fault Protection (50N/51N)
- A flag indicator shall be installed for signaling the occurrence of trip conditions.
- The Relay shall be provided with internal rechargeable battery as a backup.

## 5.2 Features and Characteristics

The numerical relay shall have the following minimal features and characteristics noting that variations may be acceptable as long as they provide similar or better functionality and/or flexibility:

- It shall be housed in a flush mounting case, draw out type and powered by the RMU power supply unit also.
- The Relay shall have capability to display currents from 1Amps.
- It shall have three phase overcurrent elements and one earth fault element.
- IDMT trip current settings shall be 10-250% in steps of 1% for phase overcurrent and 5-250% in steps of 1% for earth fault. The Time Multiplier Setting (TMS) shall be adjustable from 0.01s to 2s in 0.01s steps.
- Instantaneous trip current settings shall be 50-3000% in steps of 50% for phase overcurrent and 50-1500% in steps of 50% for earth fault. The Time element shall be adjustable from 0s to 1.5s in 0.01s steps.
- Instantaneous characteristics: The Time Element should start from"0" (zero value), type test reports are required, that how much time will relay take to trip with "Time Element =0 and also with Time delay when the fault current is injected in multiples of the rated CT.
- Selectable IDMT curves shall be provided to include, for example, Normal Inverse (3.0, 1.3), Very Inverse, Extreme Inverse, Long Time Inverse, and Definite Time. Separate curve settings for phase overcurrent and earth fault shall be supported.
- The relay shall have local independent LED indications for Healthy, Trip, I>, I>>, Ie>, and Ie>> conditions.
- Relay reset provisions shall be provided through modbus.
- The relay shall also be provided with:
  - Cold load pickup protection features shall be provided (The range shall be considered same as of IDMT and Instantaneous characteristics).
  - Circuit breaker failure protection feature shall be provided (The TMS range 0.05-2sec in steps of 0.01 sec)
  - The fault current sensing feature in relay shall be implemented as per standards.
  - Total Break time: This feature shall be included in fault records of relay which includes Relay fault sensing time, Relay operating time, arc quench time and breaker open time (Fault Clearence time).
  - LCD Display for measurement and relay setting.
  - Communications via a MODBUS RS485 port to provide the RTU (and hence the DAS) with phase current measurements. It is also desirable that this same means of communication can be used by the RTU to send setting and control commands to the relay.
  - Front USB port for local communications with a laptop PC.
  - Parameter change capability that is password protected.
  - Capability to record up to 20 of the latest fault records duly time stamped and stored in non-volatile memory for subsequent reading via the above referenced USB port.
  - Relays shall be of 24 V DC auxiliary type.

- Relay should have facility to Relay trip & latch Reset and Relay setting control through Modbus.
- The RTC back up battery shall be maintenance free and life span shall be minimum 10yrs and easily replicable.
- Boot up time of the relay in the absence of external supply/Battery backup should be minimum.

# 6 Power Supply

SPB shall be outfitted with a power supply, including batteries and battery charger, suitable for operation of SPB

The following operational specifications shall apply:

- The power supply unit shall conform to the following requirements:
  - Input: 230 VAC nominal from the RMU's auxiliary power transformer allowing for possible variations from 190 to 300 VAC.
  - Output: Stable 24 VDC for powering Relay, Meter, RTU and motor circuit, etc and 12 VDC for Radio/modem.
  - Batteries: 2 Numbers of Lithium Iron Phosphate (LiFePO4) (LFP) 12 VDC, 42Ah each.
  - Each Lithium Iron Phosphate (LiFePO4) battery system shall be provided with an integrated BMS providing : cell voltage and temperature monitoring, state-of-charge and state-of-health estimation, cell balancing, over/under-voltage, over/under-temperature, over-current and short-circuit protection.
  - Battery compartment shall feature a theft-proof enclosure of 2mm thick stainless steel (Grade 316, IP54 rated), secured solely by M8 shear-head vandal-proof nuts/bolts. Tamper detection via NC micro-switch on seams/hinges shall trigger a 100 dB piezoelectric hooter with LED strobe (latched, DC-backed), silenced via separate external "Acknowledge" button while retaining LED, and reset via distinct "Reset" button post-rectification; alarms integrate with RTU/SCADA. All wiring, including battery links and sensors, shall use armored cut-proof cables (2.5 sq mm copper with steel braid/sheath resistant to cutters/grinders).
  - Receptacles: 2 x 230 VAC (for test equipment)
  - Lighting Fixtures shall be provided for Control cabinet.
- The auxiliary power transformer's inputs shall be equipped with surge protection devices with relevant IEC standards.
- The 24 VDC Lithium Iron Phosphate (LiFePO4) batteries shall have sufficient capacity to supply power to the following devices with a nominal backup of 8 hours:
  - RMU's spring-charge motors for a minimum of six (6) operations
  - RMU's trip coils, close coils, FPI, multifunction meters, and relays

- RTU & Communication accessories.

- The batteries shall be of Lithium Iron Phosphate (LiFePO4) type and shall have a minimum life of five (10) years at 25ºC.
- The battery charger shall be fully temperature compensated.
- To prevent deep discharge of the batteries on loss of AC power source, the battery charger shall automatically disconnect all circuitry fed by the batteries following a user-adjustable time period or when the battery voltage falls below a preset value. If the battery voltage falls below the preset value, the time to fully recharge all batteries shall not exceed 8 hours.
- An automatic battery checking device shall be provided to check the battery's health and initiate a battery-failed alarm signal in case battery deterioration is detected. Such detection may be based on comparing measurement values with set values (e.g., internal resistance, voltage, etc.).
- The battery charger shall be provided with an alarm displayed at the local control panel and remotely at the DAS to account for any of the following conditions:
  - Low battery voltage
  - High battery voltage
  - Battery failed
  - Battery charger overvoltage
  - Grounded battery/battery-charger
  - Battery Temperature.
  - Others according to manufacturer's design

# 7 Multi-Function Meter

The SPB shall be equipped with Intelligent Electronic Devices (IEDs) in the form of communicable multi-function meter capable of providing distribution system voltage, current, power factor, power angle, phase angle between voltage and current of all the three phases and energy readings.

## 7.1 Operational Features

The multi-function meters shall have an accuracy class of 0.2S and shall provide data on an RS 485 communications port using the MODBUS protocol.

Each multifunction meter shall have the following minimum features:

- Measurement, display, and communications capability of up to 31 parameters
- THD measurement and power quality data
- True rms measurement
- Digital communications

- Fully programmable PT and CT ratios
- Simple menu driven interface
- High quality LED display □
- Able to monitor:
  - Voltage: line-to-line and line-to-neutral
  - Current: phase and neutral
  - Frequency
  - Phase angle between voltage and current of all the three phases
  - Power factor
  - Power angle
  - Power (active, apparent, and reactive)
  - Energy (active and reactive)
  - Total harmonic distortion

## 7.2 Specifications

The following table summarizes the specifications applicable to the multi-function meter.

*Table 7-1: Multi-Function Meter Specifications*

| Parameter | Value |
|---|---|
| Input Voltage:<br>Nominal input voltage (AC rms)<br>Max continuous input voltage | <br>57.7 – 277 V L-N, 100 - 480 V L-L<br><br>120% of nominal value |
| Input Current:<br>Nominal input current<br>System CT primary values<br>Max continuous input current | <br>1 or 5A AC rms (programmable on site)<br>Standard values up to 4 kA (1 or 5 A)<br>120% of rated value |
| Overload Withstand:<br>Voltage<br>Current | <br>2 x rated for 1 sec, repeated 10 times at 10 sec intervals<br>20 x rated for 1 sec, repeated 5 times at 5 minutes |
| Operating Measuring Ranges : | |
| Current | 5 to 120% of rated value |
| Frequency | 40 to 70 Hz |
| Power Factor | 0.5 lag to 0.8 lead |
| Power Angle | Phase Angle Accuracy: **±1** Electrical . |
| phase angle between voltage and current of all the three phases, | Phase angle accuracy: **±1° to ±2°** (as per IEC 61557 / IEC 62053-22) |

| | |
|---|---|
| Accuracy Reference Conditions: | |
| Reference temperature | 23°C ± 2°C |
| Input waveform | Sinusoidal (distortion factor 0.005) |
| Input frequency | 50 or 60 Hz ±2% |
| Auxiliary supply voltage | Rated Value ±1% |
| Auxiliary supply frequency | Rated Value ±1% |
| Power Factor | 0.866 lag to 0.866 lead |
| Accuracy: | |
| Voltage | ±0.5% over 50 to 100% of rated value |
| Current | ±0.5% over 10 to 100% of rated value |
| Frequency | 0.15% at mid frequency |
| Active Power | ±0.5% over 10 to 100% of rated value |
| Re-Active Power | ±0.5% over 10 to 100% of rated value |
| Apparent Power | ±0.5% over 10 to 100% of rated value |
| Active Energy (kWh) | 1% (IEC 62053-21) from 0.866 lag to 0.866 lead |
| Reactive Energy (kVArh) | 1% (IEC 62053-21) from 0.866 lag to 0.866 lead |
| Apparent Energy (kVAh) | 1% |
| Phase Angle and Power Factor | 1 % |
| Applicable Standards: | |
| Comprehensive EMC/ Immunity | IEC 61000-4 series |
| Safety | IEC 61010-1-2010+A1:2016 |
| IP for water and dust | IEC 60529 |
| Environmental: | |
| Operating temperature | -10 to +55°C |
| Relative humidity | 0 to 90% non-condensing |

# 8 Distribution Automation System Interface

The SPB shall be equipped so that it can be monitored and controlled via the DAS. The FRTU in the SPB in turn will interoperate with the DAS via the remote radio/any other communication system supplied by employer and the communications system to which the it is linked.

The SPB shall have provisions for opening and closing its switches using HMI of FRTU housed in the control cabinet. The SPB shall also supply analog and status signals to the FRTU for monitoring the condition of the breaker and as well as the components of the SPB. An DI indication for execution of DO command to RTU for open and close of CB shall be provided.

A list of input/output points required is presented in table below.

Table 8-1: Data Points as per SPB Configuration

| DIGITAL INPUT | CONTROL OUTPUT | IED DATA |
|---|---|---|
| CB<br>▪ CB : closed<br>▪ CB : open<br>▪ Spring : charged<br>▪ Earth switch : closed<br>▪ Earth switch : open<br>▪ Overcurrent relay : operated<br>▪ Earth fault relay : operated<br>▪ CB : local/remote status<br>▪ Door: open<br>▪ Isolator: open/close<br>▪ DI indication for execution of DO command for open and close of CB.<br>Miscellaneous<br>▪ $SF_6$ Pressure: Low<br>▪ Charger AC: Fail<br>▪ Voltage DC: Low<br>▪ Battery alarms: Battery failed, etc.<br>▪ Control cabinet Door: open<br>▪ Battery compartment :open<br>▪ Relay reset | CB<br>▪ CB : close<br>▪ CB : open<br>▪ Hooter rest | Multifunction Meter<br>Communication on MODBUS through 485 ports (1 meter)<br>No. of Measurements:<br>▪ Voltage: 3<br>▪ Current: 3<br>▪ Active power: 3<br>▪ Reactive power: 3<br>▪ Power factor: 1<br>▪ Active Energy: 1<br>▪ Reactive Energy: 1<br>▪ Power angle:3<br>▪ Phase angle: 3<br><br>Protection Relay<br>Communication on MODBUS through RS-485 ports Minimum No. of Points:<br>▪ Trip indication and remote reset.<br>▪ Other points for Relay<br>General<br>▪ Meter offline status<br>▪ Relay offline status |

## 8.1 Multi-Function Meter Interface

The Contractor is required to furnish the SPB's meter information that pertains to interfacing the meter with the FRTU through an RS 485 serial communications link.

The protocol details along with the MODBUS mapping data as implemented in each meter shall be provided (MODBUS mapping data will be provided by BESCOM, same shall be implemented in MFM). In this respect, the Contractor shall ensure the effective communications is attained between the meter and FRTU, i.e., all parameters read by the meters shall also be immediately available to the FRTU.

## 8.2 Numerical Relay Interface with FRTU

The Contractor is required to furnish the numerical relay information that pertains to interfacing the relay with the FRTU through an RS 485 serial communications link. The protocol details along with the MODBUS mapping data as implemented in each relay shall be provided (MODBUS mapping data will be provided by BESCOM, same shall be implemented in Relay). In this respect, the Contractor shall ensure effective communications is attained between the relay and FRTU, i.e., all parameters read by the relay shall also be immediately available to the FRTU.

# 9 Cybersecurity Requirements for SPBs Protection & Metering:

## 9.1 General Compliance

The Vendor shall ensure that all Intelligent Electronic Devices (IEDs), including protective relays and multifunction meters, are designed and manufactured in accordance with the following international standards:

IEC 62443-4-1: Secure Product Development Lifecycle Requirements.

IEC 62443-4-2: Technical Security Requirements for IACS Components (Target: Capability Security Level 1 - SL1).

IEC 62351: Power systems management and associated information exchange – Data and communications security.

## 9.2 Identification and Authentication Control (IAC)

Local Authentication: The device must support local password-based authentication for both the HMI (Human Machine Interface) and any engineering ports (USB/RS-485/Ethernet).

Default Credentials: The device shall not have "hard-coded" or universal passwords. The Vendor must provide a mechanism to force a change of the factory-default password during the commissioning and also allow changing passwords.

Access Lockout: The device shall implement a temporary lockout or "cool-down" period after a configurable number of failed authentication attempts (Min: 3 attempts) to prevent brute-force attacks via the engineering port.

## 9.3 Use Control and Port Security (UC)

USB Port Management: The relay must disable "Autorun" or "Autoplay" functionality. No configuration file or firmware shall be executed or imported automatically upon USB insertion.

Manual Confirmation: Any data transfer (Upload/Download) via the USB interface must require explicit manual confirmation through the device's HMI after successful login.

Unused Ports: The vendor shall provide the capability to logically disable unused communication ports (e.g., RS-485 or Ethernet) via the device configuration settings.

## 9.4 System Integrity (SI)

Firmware Integrity: The device must perform a cryptographic checksum (e.g., SHA-256) or hash verification on all firmware updates before installation to ensure the file has not been tampered with.

Logic Protection: Protection settings, trip logic, and configuration parameters must be stored in a non-volatile memory that is protected against unauthorized modification.

## 9.5 Audit Logging and Monitoring (RA)

Security Event Logging: The device shall maintain an internal, non-volatile audit log that records at least the last 50 security-relevant events, including:

Successful and failed login attempts.

USB/Engineering port connection and disconnection events.

Modifications to protection settings or system configurations.

Firmware update attempts (Success/Failure).

Exportability: Log data must be viewable via the engineering software and, if network-enabled, exportable via standard protocols (e.g., Syslog or IEC 61850).

### 9.6 Vendor Documentation Requirements

The Vendor shall submit the following documents as part of the technical bid:

Hardening Guide: A step-by-step document explaining how to secure the device (e.g., changing passwords, disabling ports).

Vulnerability Management Policy: A statement on how the vendor identifies and notifies customers of security vulnerabilities (CVEs) in their products.

Self-Attestation: A formal letter confirming that the device meets the Capability Security Level 1 (SL-C 1) requirements of IEC 62443-4-2.

# 10 Construction

The SPB shall be sufficiently sturdy to withstand handling during shipment, installation, and start-up without damage. The configuration for shipment shall adequately protect the SPB equipment from scraping, banging, or any other damage. The Contractor shall assume responsibility for correction of all such damage prior to final acceptance of the equipment.

## 10.1 Enclosures

The enclosures shall be sized to provide convenient access to all enclosed components. It shall not be necessary to remove any component to gain access to another component for maintenance purposes or any other reason.

The enclosures shall also be designed to ensure that the enclosure remains rigid and retains its structural integrity under all operating and service conditions with and without the enclosure door closed.

If made from stainless steel (316L), the thickness of the enclosure panels shall not be less than 1.5 mm. Otherwise the thickness of all enclosure panels shall not be less than 2 mm.

The appropriate corrosion treatment and finish requirements shall apply to both inside and outside enclosure surfaces. Other required features are as follows:

- Constructed of stainless steel (316L) according to IEC 60529 with IP rating 67 or better. Alternatively, the SPB ’s metal parts shall be made of high thickness high tensile steel which must be grit/shot blasted, thermally sprayed with Zinc alloy, phosphate, and subsequently painted with polyurethane based powder paint, the overall paint layer thickness including Zinc spraying shall be of the order of 120 microns.

- Means, such as insulated heat shields and/or air vents, to prevent high temperatures from damaging the SPB 's enclosed components. If air vents are installed, these vents shall in no way reduce the effectiveness of the enclosure's protective characteristics.

- A metal pocket attached to the inside of the front door to hold documentation, maintenance log sheets, and other such information.

- Door opening mechanism with built-in key-lock facility suitable for padlocking. An opening mechanism that is less prone to breaking than a projecting door handle is preferred, e.g., a push-button opening mechanism.

- A grounding terminal including grounding bolt and lock washer for connecting a 50 $mm^2$ galvanized steel grounding conductor. The grounding bolt and lock washer shall be made of stainless steel.

- Means of preventing moisture from condensing on electronic components mounted inside the enclosure proposed for housing the FRTU. If necessary, heaters providing adjustable thermostat-control within the range 20 to 60 ºC shall be installed in the enclosure for this purpose.

- Means of protection against rain water, corrosive salt formations, and high levels of airborne dust.

- Means of enabling the DAS to monitor the open/closed status of the enclosure door. A DAS equipment alarm shall be produced whenever the enclosure door is open.

## 10.2 Control Cabinet

The SPB shall be outfitted with a separate enclosure, referred to herein as the Control Cabinet, to house the following equipment as a minimum:

- Auxiliary transformer 500 VA
- SCADA terminal blocks
- Power Supply Unit including Li-ion Batteries
- FRTU
- Communication system
- Multi-pin connector consisting of plug and socket fittings and angled terminal block
- Other equipment according to manufacturer's design

The Control Cabinet shall be similar in style and finish as the other SPB's enclosures. This shall include having a minimum protection class of IP 56 or better. It shall be tested in accordance with the latest IEC 60529 standards.

The cabinet shall have a hinged front access door with a three-point latch locking system and a latch operating lockable handle. The door shall be fitted with a perimeter flange and gasket (rubber or neoprene) to prevent the entrance of water. In addition, a means of monitoring and indicating that the door is open shall be provided.

A metal screen with holes shall be provided on the top and bottom of the control cabinet to provide ventilation aimed at avoiding condensation inside. Venting however shall in no way reduce the effectiveness of the control cabinet's water-tight, dust-tight, and corrosion-resistant characteristics. To augment the cabinet's effectiveness in preventing the ingress of dust, insects, vermin, and small objects, all electronic parts within the control cabinet shall be enclosed in modules. Such parts and modules shall be separated from the power supply module as also installed in the cabinet.

The Control Cabinet shall include a weather-sealed hole with a double compression cable gland, approximately 30 mm in diameter, on the top of the cabinet for routing an antenna cable that will be supplied and installed by BESCOM.

If made from stainless steel (316L), the thickness of the enclosure panels shall be at least 1.5 mm. Otherwise the thickness of all enclosure panels shall be at least 2 mm.

The control cabinet shall also be provided with:

- Weatherproof fittings for control cables.
- Provision for handle and padlock.
- Grounding terminal, with solderless clamp type connector suitable for steel stranded conductor of suitable diameter and complete with lock washer of stainless steel or better.
- Provision for separately grounding the SPB electronic items.
- Thermally controlled small fan for circulating air when necessary to maintain temperatures within the Control Cabinet to acceptable levels.
- Circuit diagram of control unit for maintenance purpose affixed permanently.
- Others according to manufacturer's design.

# 11 Auxiliary Transformer

The SPB shall be outfitted with a single-phase auxiliary power transformer with a turns ratio of 11000/sqrt (3) to 230, i.e., it shall be connected line-to-neutral to the SPB 11 kV bus and used to provide the required 230 VAC input to the SPB 's power supply. The capacity of the auxiliary power transformer shall be 500 VA. During project implementation, however, the Contractor shall assess this requirement by taking into account the actual load corresponding to the FRTU and other communication system (supplied by employer) as well as the load represented by the breaker's SPB motors, etc. In this respect, with a suitable margin approved by the Employer, the auxiliary transformer must be capable of supporting the power supply requirements that correspond to SPB. HRC fuses shall be provided on HV side and suitable capacity MCB on LV sides of the transformer.

# 12 Motors

The SPB shall be retro-fitted with spring charge motors of insulation Class E or better allowing the circuit breaker to be operated without manual intervention. Motor speed shall ensure springs can be charged automatically. Independently of DAS control, the mechanism shall ensure that the motors start up immediately once the spring becomes discharged, so that the breaker becomes ready for the next operation.

In addition to allowing circuit breaker tripping by the SPB 's protection relays, the motorized operating mechanism shall be suitable for remote control by the DAS. The motors along with a Contractor supplied control panel shall allow Employer personnel to electrically operate the circuit breaker at site without any modification of the operating mechanism and without de-energizing the breaker.

The motors shall be of a reputable make in the form of a universal 24 VDC type. They shall be enclosed and completely dust proof and sized with a suitable margin to meet the torque requirement of the spring charge mechanism. The motor shall be within the enclosures.

No SPB installation shall be accepted as complete until the Employer is satisfied that all variances associated with an individual site have been corrected and that the SPB is SCADA ready, i.e., can be considered fully integrated with the DAS.

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